

## METHOD AND SYSTEM FOR LOCATING A MOBILE STATION

### BACKGROUND OF THE INVENTION

The present invention relates to a mobile station locating method for locating a mobile station by utilizing a mobile communication system and also relates to a mobile station locating system for realizing this method. Specifically, the present invention makes it possible to reduce the burden in the calculation (amount and time) required for this locating operation.

According to a conventional mobile communication system, a stable communication between a mobile station and a base station is performed in the following manner. The mobile station measures a field intensity of a radio transmitting line to each neighboring base station, and selects a desirable base station having the highest field intensity. Then, the position of the mobile station is registered in a radio zone of the selected base station. In this manner, a stable radio transmitting line is secured between the mobile station and an optimum base station.

Furthermore, after having secured the most reliable radio transmitting line to the optimum base station, the mobile station intermittently executes the measurement of the field intensity etc. Due to a shift movement of the mobile station, the field intensity to the present base station may become weaker than a field intensity to other base station. This will decrease the reliability of communications significantly. In such a case, the registration of the mobile station's position is renewed from the present station to the next station. Then, the radio transmitting line is switched to a new station. In this manner, an optimum communication line is always secured.

However, according to the conventional mobile communication system, the position of the mobile station can be roughly grasped by the size of a radio zone of a base station. It is however impossible to identify the position of the mobile station precisely at the units of a smaller area.

If identifying the position of the mobile station is feasible, it becomes possible to utilize the positional information of own or a desired mobile station by accessing from the mobile station or via a general telephone. The obtained positional information can be used in various ways. Furthermore, the base station can memorize the positional information of the mobile station. The stored positional information can be utilized as useful data in the processing of various information, such as utilization rate or statistical processing of mobile stations in the radio zone.

Identifying the position of the mobile station can be realized by utilizing a GPS which is widely used these days. In this case, the mobile station needs to incorporate a new system which has not ever used. In view of the foregoing, to identify the position of the mobile station, it is preferable that the mobile station can utilize existing functions of a conventional mobile communication system without largely modifying the existing system. Some methods have been always proposed.

According to Unexamined Japanese Patent Application No. 7-38951, a mobile station transmits a position detecting signal including information for self-identification. At least three neighboring base stations receive this signal and detect a field intensity of the received signal. A central exchange station, connected to each base station, calculates a position of the mobile station based on the information relating to the field intensity of the received signal supplied from each base station. According to this prior art, the central exchange

station calculates a distance between the mobile station and each base station based on the field intensity of the received signal. A circle with its center on each base station and having a radius identical with the calculated distance is drawn with respect to each base station. Then, an intersection of the drawn circles is identified as the position of the mobile station.

Furthermore, according to Unexamined Japanese Patent Application No. 3-235077, at least three base stations communicate with a mobile station. A delay time, which corresponds to a time required for a reciprocative radio wave propagation between each base station and the mobile station, is calculated. Then, based on the delay time obtained in each base station, the position of the mobile station is calculated.

However, the above-described mobile station locating methods are characterized in that the position of the mobile station is obtained as a point, and therefore disadvantageous in that a long calculating time is required and a large calculation error may be caused.

FIG. 7 is a schematic view showing a conventional mobile station locating method. According to one method for identifying the position of a mobile station 31, a delay time of a received signal is utilized. Namely, delay times  $\Delta t_1$ ,  $\Delta t_2$  and  $\Delta t_3$  correspond to reciprocative radio propagation times between the mobile station 31 and the base stations 21, 22 and 23, respectively. Using the measured delay times  $\Delta t_1$ ,  $\Delta t_2$  and  $\Delta t_3$ , distances between the mobile station 31 and respective base stations 21, 22 and 23 are calculated. Then, the position of the mobile station 31 is identified based on the calculated distances from three points of respective base stations 21 to 23.

According to the other method for identifying the position of the mobile station 31, a field intensity of the received signal is utilized. Namely, field intensities R1 to R3 represent the attenuation of the radio waves between the mobile station 31 and the base stations 21, 22 and 23, respectively. Using the measured field intensities R1 to R3, distances between the mobile station 31 and respective base stations 21, 22 and 23 are calculated. Then, the position of the mobile station 31 is identified based on the calculated distances from three points of respective base stations 21 to 23.

However, identifying the mobile station's position as a point is disadvantageous in that a significant amount of calculation error may be caused depending on shifting conditions, such as shifting speed and direction of the mobile station, or radio wave propagating conditions, such as seasons, times, geography, weather, magnetism etc. Especially, in a mobile communication system utilizing microwaves, the calculation error tends to be enlarged due to interactions between the above-described various error factors. Furthermore, when the calculation error needs to be reduced as small as possible, a sophisticated calculation method will be required for calculating the delay times or the field intensities. This increases the calculation time largely.

### SUMMARY OF THE INVENTION

To solve the above-described conventional problems, the present invention has an object of providing a mobile station locating method which is capable of enlarging an allowable error range in the calculation and reducing the total calculation time. Furthermore, the presents invention provides a mobile station locating system performing the above-described locating method.

In order to accomplish the above-described and other related objects, the present invention provides a novel and